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Risk Prediction of Morbidity and Mortality in Emergency Laparotomy by Possum Equation

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ABSTRACT

POSSUM (Physiological Operative Severity Score for enUmeration of Mortality and morbidity) is a simple scoring system, described and validated in developed countries. Application of POSSUM to developing countries with a different population and level of resources is limited. In the present prospective study POSSUM scoring system is applied to determine how it performed in predicting complication or death in patients undergoing emergency laparotomy. A total of 72 emergency laparotomies were performed. The risk of complication and death was calculated using POSSUM equation. The estimated rates were compared with observed rates using linear by linear association of chi-square test. Possum equation clearly predicted morbidity and mortality rates with linear by linear association of chi square test P value of 0.006 and ‹0.001 respectively. The ROC curve shows the predictive potential of POSSSUM for mortality with a sensitivity of 100%, specificity of 84% and area under the curve 97.2%. Our study shows that POSSUM equation is valid in predicting death of patients undergoing emergency laparotomy. POSSUM equation of morbidity estimated complications comparable to observed rates. If this finding is validated it may be possible to use possum to improve the emergency services.

Keywords-risk prediction, POSSUM, emergency laparotomy, validation

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INTRODUCTION

The outcome of surgical intervention, whether death, complications or long term morbidity is not solely dependent on the abilities of surgeon in isolation. The patients physiological status, the disease that requires surgical correction, severity of disease, the nature of the operation and the pre-operative and post-operative support services have a major effect on the ultimate outcome. It is evident to surgeons that mortality and morbidity rates do little to explain these differences, and that the use of such statistics is at best inaccurate and misleading [1]. To provide comparative audit between different populations, measures of outcome must include methods to accommodate for differences in case mix [2]. Operative mortality is an important and objective measure of outcome [2]. Monitoring of outcome is an increasingly important part of the governance of surgical activity. Patients value information concerning mortality and morbidity rates of surgical procedures. Thus there has been a search for accurate risk scoring systems that can be used to compare patient outcomes according to different units and hospitals [3].

Risk scoring systems should quantify a patient's risk of death or morbidity based on the severity of illness derived from data available at an early stage of the hospital stay. It is currently of particular importance in surgical practice [4]. Many scoring systems were developed that predict the risk of mortality with varying degrees of accuracy. Many scores have been devised which are ideally suited to special types of surgical procedure or to assessing particular types of complications. The ideal scoring system for the surgical audit purposes should assess mortality and morbidity and allow audit retrieval of surgical success. It should be quick and easy to use and should be applicable to all general surgical procedures in both the emergency and elective setting. It should be of use in all types of hospitals and should provide educational information [5].

With this in mind a system was developed to allow for the first time an assessment of surgical quality that was risk adjusted for the patient's acute and chronic physiological status and for the nature of operation. By using a process of multivariate discriminate analysis, a scoring system was developed that could accurately predict 30 day mortality and morbidity. The POSSUM audit system (The Physiological and Operative Severity Score for enUmeration of Mortality and morbidity) was designed to be easy and rapid to use and to have wide application across the general surgical spectrum both in the elective and emergency settings [1]. In the present study POSSUM scoring system was applied prospectively to determine how they performed in predicting death in patients undergoing emergency laparotomy in our hospital, a group known to be at high risk of complications and death.

MATERIALS AND METHODS

All the patients who underwent emergency laparotomy at our hospital between November 2010 to July 2012 were included in this prospective study. Patients who were under the age of 14 years and who underwent laparotomy for gynecological causes were excluded from the study. Data was collected prospectively on a proforma prepared for the study from

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the patients undergoing emergency laparotomy. All such patients would have their physiological score recorded on admission. An operative severity score was calculated based on findings recorded by the operating surgeon on the proforma. The risk of morbidity and death was calculated using POSSUM equation.

POSSUM equations:

1) Log R_1 / 1-R_1 = -7.04 +(0.13 x physiological score) + (0.16 x operative severity score)
2) Log R_2 / 1-R_2 = -5.91 + (0.16 x physiological score) + (0.19 x operative severity score)

R_1 = risk of mortality R_2 = risk of morbidity

POSSUM (Physiological and Operative Severity Score for the enUmeration of Mortality and morbidity) was first described by Copeland et al[5] in 1991 as a method for standardizing patient's data so that direct comparisons of patient outcome could be made despite differing patterns of referral and population[6].They originally assessed 48 physiological factors and 14 operative and post operative factors for each patient. Using multivariate analysis techniques these were reduced to 12 physiological and 6 operative factors which are summarized in TABLE 1. The POSSUM is a 2 part scoring system that includes a physiological assessment and a measure of operative severity. The physiological part of the score includes 12 variables, each divided into 4 grades with an exponentially increasing score (1, 2, 4 and 8). The physiological variables are those apparent at the time of surgery and include clinical symptoms and signs, results of simple biochemical and hematological investigations, and electrocardiographic changes. Highest score being given to the most deranged values. If a particular variable is not available, a score of 1 is allocated. Some variables may be assessed by means of clinical symptoms or signs or by means of changes on chest radiographic findings. The minimum score, therefore, is 12, with a maximum score of 88[1].

TABLE 1 : POSSUM PHYSIOLOGICAL AND OPERATIVE PARAMETERS

Physiological parameters	Operative parameters
- Age	- Operative severity
- Cardiac history	- Multiple procedures
- Respiratory history	- Total blood loss
- Blood pressure	- Peritoneal soiling
- Pulse rate	- Presence of malignancy
- Glasgow coma score	- Mode of surgery
- Haemoglobin level	
- White cell count	
- Urea concentration	
- Na^+ level	
- K^+ level	
- Electrocardiography	

The POSSUM physiology score based on these preoperative factors was predictive of outcome for individual operations, but not for groups of surgical patients as a whole. For example, a patient having an aortic aneurysm repair was likely to have a higher probability of

death than the same patient having a pilonidal abscess drained. To address this, a six-factor operative severity score was added using similar methodology [7]. POSSUM scores derived from the physiological values is a measure of pre-operative severity of illness. POSSUM has the advantage of including operative severity variables, which made it better in predicting morbidity and mortality rates.

TABLE 2: PHYSIOLOGICAL AND OPERATIVE SEVERITY ASSESSMENT FOR THE POSSUM SYSTEM

Score	**1**	**2**	**4**	**8**
Age years	≤ 60	61-70	≥ 71	-
Cardiac signs CXR	Normal Normal	Cardiac drugs or steroids -	Edema; warfarin Borderline cardiomegaly	JVP Cardiomegaly
Respiratory signs CXR	Normal Normal	SOB exertion Mild COAD	SOB stairs Mod COAD	SOB rest Any other change
Systolic BP, mm Hg	110-130	131-170 100-109	≥ 171 90-99	≤ 89
Pulse beats / min	50-80	81-100 40-49	101-120	≥ 121 ≤ 39
Coma score	15	12-14	9-11	≤ 8
Urea nitrogen, mmol/L	< 7.5	7.6-10	10.1-15	≥ 15.1
Na mEq/L	> 136	131-135	126-130	≤ 125
K mEq/L	3.5-5	3.2-3.4 5.1-5.3	2.9-3.1 5.4-5.9	≤ 2.8 ≥ 6
Hb. g/dL	13-16	11.5-12.9 16.1-17	10-11.4 17.1-18	≤ 9.9 ≥18.1
WBC x 10^{12}/L	4-10	10.1-20 3.1-3.9	≥ 20.1 ≤ 3	-
ECG	Normal	-	AF (60-90)	Any other change
Score	**1**	**2**	**4**	**8**
Operative magnitude	Minor	Intermediate	Major	Major +
No. of operations within 30d	1	-	2	>2
Blood loss per operation, mL	< 100	101-500	501-999	> 1000
Peritoneal contamination	No	Serous	Local pus	Free Bowel content, pus or blood
Presence of malignancy	No	Primary cancer only	Node metastases	Distant metastases
Timing of operation	Elective	-	Emergency resuscitation possible, operation < 24 hr.	Emergency immediate, operation < 2hr.

Physiological and operative severity assessment for the POSSUM system (Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity). In some variables, signs may be assessed clinically and / or by changes in results on chest X-ray film (CXR). Ellipses indicate not applicable; JVP, jugular venous pressure; SOB, shortness of breath; COAD, chronic obstructive airway disease; Mod. Moderate; BP, blood pressure; Na, sodium; K, potassium; Hb, hemoglobin; WCC, white blood cell count; ECG, electrocardiogram; and AF, atrial fibrillation.

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TABLE 3 : EXAMPLES OF SURGICAL MAGNITUDE FOR GENERAL SURGERY

Minor

- Hernia
- Varicose vein
- Minor perianal surgery
- Scrotal surgery
- Minor TURT
- Excision of large subcutaneous lesion

Intermediate

- Open cholecystectomy
- Laparoscopic cholecystectomy
- Appendectomy
- Excision of lesion requiring grafting or minor excision
- Minor amputation
- Thyroid lobectomy

Major

- Laparotomy
- Colonic resection or anterior resection
- Major amputation
- Nonaortic vascular surgery
- Cholecystectomy and exploration of bile duct
- Total thyroidectomy

Major +

- Abdominoperineal excision of rectum
- Aortic surgery
- Whipple resection
- Radical total gastrectomy

* TURT indicates transurethral resection of tumor.

The operative severity part of the score includes 6 variables, each divided into 4 grades with exponentially increasing score (1, 2, 4 and 8). The number of operations indicates the chronology of the procedure(s) within 30 days [1]. The physiological and operative scores are obtained by applying the preoperative physiological values and operative severity variables to physiological and operative severity assessment table for the POSSUM system as developed by Copeland et al [5] shown in TABLE 2. AND 3. Once the scores are known, it is possible to estimate the predicted risk for mortality and morbidity using the following equations.

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1) $\text{Log}_e \frac{R_1}{(1-R_1)}$ = – 7.04+ (0.13 x P.S) + (0.16 x OS)

2) $\text{Log}_e \frac{R_2}{(1-R_2)}$ = – 5.91 + (0.16 X P.S) + (0.19 x OS)

R_1 indicates mortality and R_2 morbidity.

The POSSUM mortality equation was found to over predict deaths. This over prediction was greatest amongst low risk patients (those with a risk of mortality of 10% or less), who form the majority of general surgical patients. The approach was then modified using the above standard methods to obtain and logistic regression model that fitted well with the observed mortality. The patients were followed in the post-operative period. The development of any complications during the stay in hospital were observed and recorded in the complication chart.

TABLE 4: COMPLICATION CHART

1) Haemorrhage :
• Wound
• Deep
Infection :
2) Chest
3) Wound
4) UTI
5) Deep
6) Septicemia
7) PUO
8) Others
Wound dehiscence :
9) Superficial
10) Deep
11) Anastomotic leak :
Thrombosis :
12) DVT
13) PE
14) CVA
15) MI
16) Cardiac failure
17) Impaired renal function : (urea increase > 5 mmol/l, from preoperative level)
18) Hypotension (< 90mm Hg for 2h)
19) Respiratory failure :
20) Any other complications

UTI, urinary tract infection; DVT, deep venous thrombosis; PE, Pulmonary embolism; CVA, cerebrovascular accident; MI, myocardial infarction; PUO, pyrexia of unknown origin

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RESULTS

In the present study 72 patients undergoing emergency laparotomy were taken to study POSSUM equation. The following observations were made. Among the patients studied 87.5% patients were less than 60 years of age, 12.5% were between 61-70years.male patients were 69.4% and 30.6% were females. 29.2% of patients were operated for appendicular pathology followed by 26.4% with bowel obstruction, 15.3% duodenal perforation, 6.9% gastric perforation, 4.2% jejunal perforation, 8.3% ileal perforation, 1.4% liver pathology, 2.8% gall bladder pathology, 2.8% intraabdominal abscess, 2.8%abdominal trauma. 91.3% patients had cardiovascular signs normal, 8.3% had abnormal signs. 81.9% of patients had normal respiratory signs, 18% had COPD (Chronic obstructive pulmonary disease). 62.5% had systolic blood pressure between 110-130mmof Hg, 29.2% had pulse rate between 50-80, 54.2% had pulse rate between 81-100 or 40-49. 98.6% had their GCS 15, 1.4% had GCS between12-14. Among the patients studied 29.2 % had their haemoglobin less than 9.9gm/dl,52.8% had white blood cell count in between $4x10^{12}$/L to $10x10^{12}$. 77.8% had their blood urea nitrogen less than 7.5%, 13.9% had between 10.1-15mmol/l,6.9% in between 7.6-10mmol/l and only 1.4% patients had above 15.1mmol/l. Among the patients studied 52.8% had normal Na+ levels and 27.8% had between 126-130mEq/l .75% had K+ between 3.2-3.4 or 5.1-5.3mEq/l. 72% patients had normal ECG, 4.2% had significant ST segment elevation. Among all the patients studied 55.6% had their physiological score between 11-20, 34.8% in between 21-30 and only 9.8 % had scores more than 9.8%.

Among the patients studied 97.2% belonged to major operative severity and only 2.8% had intermediate operative severity. All the patients had only one procedure.50% had blood loss ranging between 101-500ml during the procedure,38.9% less than 100ml and 11.1% between 501-999ml. 88.9% had peritoneal soiling with majority having free bowel content, Pus or blood 56.9% and 11.1% did not have any kind of peritoneal soiling. Only 5.6% of patients were found to have malignancy intraoperatively that was confirmed with histopathology of the patients studied 97.2% underwent surgery within 2 hours of admission,2.8% underwent surgery with in<2 hours of their admission. Among 72 patients studied 87.5% of patients had total operative score between 11-20, 12.5% had score between 21-30.There were no patients with score more than 30.Among the patients studied 73.6% of patients encountered post operative complications, Post operative pyrexia being the commonest(56.9%) followed by wound infection(30.5%).only 26.4% had no post operative complications.(TABLE-5)

When the observed and expected morbidity rates for possum was compared with linear by linear association of chi-square test analysis POSSUM equation was found to be clearly predicting the morbidity rates with a P value of 0.0006.(TABLE 6) The ROC (Receiver operating characteristic) curve shows the Predictive potential of POSSUM for Mortality with a Sensitivity of 100%, Specificity of 84.13% and area under curve of 97.2% for POSSUM. (FIGURE 1)

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TABLE 5: COMPLICATIONS OF THE PATIENTS.		
Complications	**Number of patients(n=72)**	**Percentage-%**
Nil	19	26.4
Present	53	73.6
1.Haemorrhage-wound	2	2.8
2.Haemorrhage-deep	1	1.4
3.Chest infection	18	25.0
4.Wound infection	22	30.5
5.UTI	13	18.02
6.Deep infection	2	2.8
7.Septicaemia	5	6.9
8.PUO	41	56.9
9.Others	4	5.6
10.Superficial wound dehiscence	15	20.8
11.Deep wound dehiscence	1	1.4
12.Anastomotic Leak	-	-
13.DVT	-	-
14.PE	-	-
15.Other	-	-
16.CVA	-	-
17.MI	1	1.4
18.Cardiac failure	-	-
19.Impaired renal function	3	4.2
20.Hypotension	2	2.8
21.Respiratory failure	-	-
22.Any other complications.	-	-

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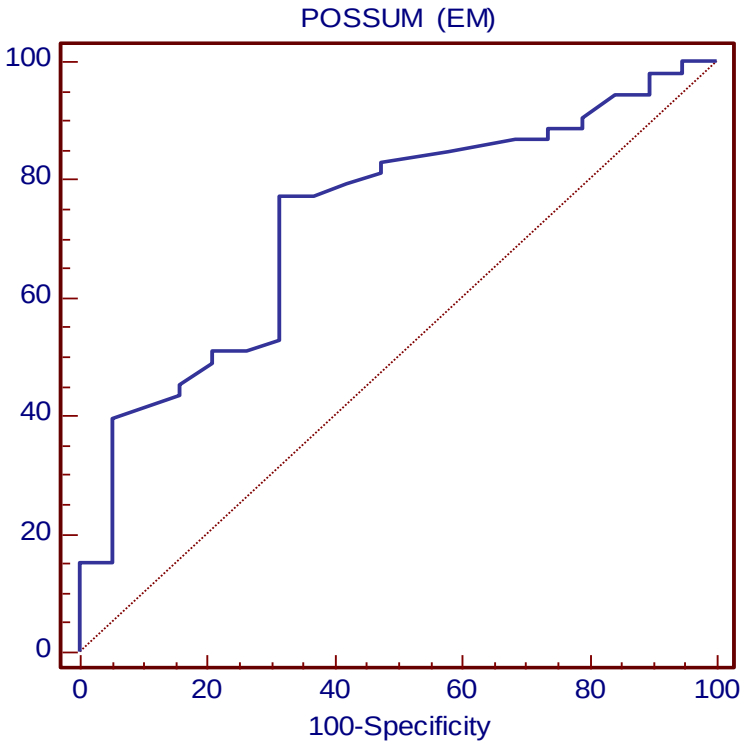
TABLE 6: OBSERVED AND EXPECTED MORBIDITY ACCORDING TO POSSUM.

POSSUM%	Number of patients	Observed Complications	Expected Complications	Cumulative Expected Complications
1-10	0	0	0.0	0
11-20	1	0	0.7	0.7
21-30	5	3	3.7	4.4
31-40	4	3	2.9	7.3
41-50	12	5	8.8	16.1
51-60	9	7	6.6	22.7
61-70	11	9	8.1	30.8
71-80	15	12	11.0	41.8
81-90	6	6	4.4	46.2
91-100	9	8	6.6	53.0

Linear-by-Linear association with P=0.006**



GRAPH 1 – SENSITIVITY, SPECIFICITY FOR MORBIDITY - POSSUM.

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DISSCUSSION

Morbidity and mortality continue to be of importance as the quality of care is being judged by morbidity and mortality rates. In a set up like ours, where the patients undergo emergency laparotomy for diverse etiologies, patient's nutritional status, co morbid conditions, availability of limited resources, post-operative supportive care plays important role in the quality of care. So it is not just enough to measure quality of care with morbidity and mortality rates.

In our prospective study a total 72 patients underwent emergency laparotomy. A total of 9 deaths were observed. The expected complication and death rates were predicted by using POSSUM equations. When the observed and expected morbidity rates for POSSUM was compared with linear by linear association of Chi-square test analysis [25]. POSSUM equation was found to be clearly predicting the morbidity rates with a P value of 0.006. When the observed and expected mortality rates for POSSUM was compared with linear by linear association of Chi-square test analysis[25] POSSUM equation was found to be clearly predicting mortality rates with a P value of <0.001.

The ROC curve shows the Predictive potential of POSSUM for mortality with a Sensitivity of 100%, Specificity of 84.13% and area under curve of 97.2% for POSSUM. Mohil RS et al [8] compared POSSUM and P- POSSUM for predicting the adverse outcome rate in patients undergoing emergency laparotomy. They concluded by validating POSSUM and P- POSSUM scoring systems for accurate prediction of post operative mortality rates even in the Indian scenario, where the patients usually belonged to the low socioeconomic strata with very limited resources. Jones DR, Copeland GP, de Cossart L[13] compared POSSUM with APACHE II for prediction of outcome from a surgical high dependency unit, the POSSUM and APACHE II scores from 117 consecutive admissions, after major surgery were correlated with 30 day observed mortality and morbidity rates. The authors concluded that the POSSUM was superior to APACHE-II in prediction of mortality and postoperative complications and may be used for audit. Vollmer CM et al [21] applied POSSUM methodology for quality assessment in high acuity surgery in 296 patients undergoing pancreatic resections, the authors calculated expected morbidity using POSSUM methodology and compared it with observed morbidity. The observed and expected morbidity rates were equal (54.1% vs. 55.1%) for an OE ratio of 0.98. The authors commented that POSSUM has been validated as a satisfactory method for predicting surgical complications across multiple disciplines and across various levels of surgical procedures complexity.

CONCLUSION

In the present study POSSUM equation clearly predicted morbidity and mortality rate in patients undergoing emergency laparotomy in our hospital, a group known to be at high risk of complications and death.

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